

An Evaluation of The Impact of An Engineering Service-Learning Implementation on Learning

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Abstract: This study aims to examine the impact of the Service-Learning approach on the engineering education system and student learning. The study is conducted through the example of a specific implementation of this approach, namely the "Smile project," a collaborative initiative between universities in Morocco and South Korea. This study also provides valuable insights and recommendations to further develop this educational implementation. To assess the effectiveness of the program in enhancing student learning, the study uses pre- and post-questionnaires administered to the participating students. The results of this analysis reveal a strong positive effect of engineering service-learning as a learning approach, improving both technical and interpersonal skills of engineering students. The impact on these skills, however, varies among individuals.

Keywords: *Engineering Service-Learning, engineering education system, student learning, learning approach, educational approach.*

1. Introduction

Service-Learning is a learning approach that associates community service with educational objectives to create a practical, progressive learning experience by addressing social needs. In fact, service learning resembles problem-based learning: combining an educational experience content with an organized service activity that addresses identified community needs, and reflecting on the service activity to develop a deeper understanding of the course content, a greater appreciation of the discipline, and an increased sense of civic responsibility.

The Smile Project is a component of the Beyond Engineering Education (BEE) program, whose objective is to provide service through engineering. The collaborative educational platform of Project BEE Community integrates an Engineering Service-Learning (ESL) model, which is based on the design process, to address tangible real-world challenges. The BEE program consists of many projects, and aims to have an international committee acting as event organizers from the Community Service Hub Center. Smile project is a collaborative initiative between the University of Chouaib Doukkali in Morocco and the Pusan National University in South Korea. Since its inception in 2016, this project has brought together engineering students from both universities, representing various fields.

This study uses a qualitative approach based on questionnaires, interviews, observations, and documents. As a study example, the Smile Project last edition in face-to-face mode, which was

organized in Morocco in 2019, is considered. The objective of this study is to evaluate the impact of this approach in the 2019 edition on participating students, through the comparison of different skills and competencies of these students before and after this project.

The structure of the remaining sections in this paper is outlined as follows. The second section describes the design project of our study example, the Smile project. The third section presents the methods that were used in this study, and the fourth section details the study results, discussion, recommendations, and limitations. The last section provides a brief conclusion on the study.

2. Presentation of Smile Project

The Smile project follows a predefined process, which is executed in a face-to-face format over 10 to 11 days, with students and managers gathering in or near a rural area where the service is intended to be offered. This section describes this process.

Design Process

This project is organized as a five-task process. 'Task 1: Building the Best Team' focuses on creating the best teams in terms of composition, cohesion, and harmony. Several factors are considered to achieve this, including specialties, skills, and personality types. 'Task 2: Looking at Problems from Different Perspectives' trains students to examine problems from various angles through creative invention, design, and technical writing methods. In 'Task 3: Solving Community Problems', the project helps solve problems faced by local people. This includes developing a new concept, designing a product, purchasing materials, building the product, writing instructions, and installing it. 'Task 4: Becoming One with the Local Community' focuses on

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effective communication to ensure that locals understand who the project participants are and why they are in their community. Finally, 'Task 5: Organizing and Sharing Ideas' assists students in evaluating their personal creations, organizing them, and disseminating their ideas so that their work is valued and similar

projects can be completed in future years. Throughout the project's duration, engineering students follow a structured procedure to complete these tasks. Figure 1 illustrates the steps of this procedure.

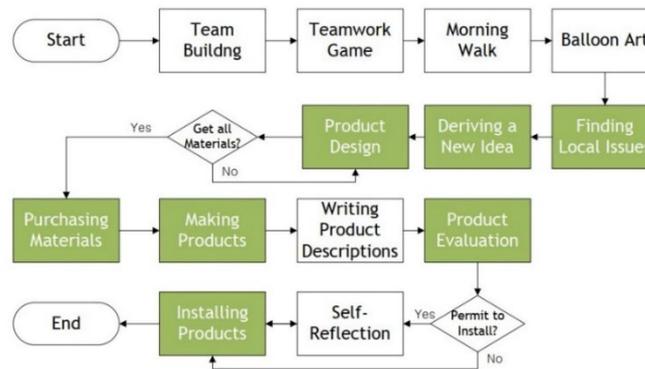


Figure 1. Design process of Smile project.

Students are selected based on their stated interest in the project, followed by interviews to assess their communication skills, particularly their English proficiency, which is the primary language of communication throughout the project duration. The participants in the 2019 version were divided into two teams of five students each, considering their personality, gender, and nationality to create balanced and homogeneous teams. Table 1

provides a summary of students' demographics in the Smile project 2019 edition. According to Table 1, it can be observed that the teams' distribution is balanced in terms of gender, nationalities, and age. Moreover, the students' majors are varied, which enables them to complement each other and foster an environment of competition and enthusiasm.

Table 1. Demographics of Students in the Smile Project 2019.

Demographics	Team 1 (EMJOY)	% (n=5)	Team 2 (MISO)	% (n=5)
Sex				
M	2	60%	3	60%
F	3	40%	2	40%
Age				
≤19	2	40%	1	20%
20	1	20%	2	40%
21	1	20%	2	40%
≥22	1	20%		
Grade				
Sophomore			2	40%
Junior	3	60%	2	40%
Senior	2	40%	1	20%
Specialty				
Industrial Engineering	1	20%		
Energetic and Electrical Engineering	1	20%	1	20%
Network and telecommunication Engineering			1	20%
Electronic Engineering	1	20%		
Materials Science and Engineering	1	20%		
Polymer Science and Engineering	1	20%	1	20%
Software Engineering			1	20%
Mechanical Engineering			1	20%
University				
PUSAN - South Korea	2	40%	3	60%
CHOUAIB DOUKKALI - Morocco	3	60%	2	40%

To optimize role specification within a team, team members have previously completed the Myers-Briggs Type Indicator (MBTI) test. The purpose of this test is to assess an individual's psychological preferences regarding how they perceive the world and make decisions, and it serves as a self-reflective tool (Cohen et al., 2013; Edwards et al., 2002; Kusuma et al., 2018). The underlying hypothesis of MBTI is that we all possess specific preferences in how we live our experiences, and these inclinations influence our needs, interests, motivation, and values (Kaplan & Saccuzzo, 2001). Each team member is assigned one of six specified roles according to their talents, majors, and psychological preferences, based on the test results (Table 2). Note that one individual is assigned two roles since the total number for each team is five engineering students.

Table 2. The Six Roles Assigned by The MBTI Test.

Job	Description
Mapper	Mapping all activity online
Journalist	Recording all progress at sheet
Designer	Drawing the product design
Scheduler	Check the Schedule and activity
Communicator	Reporting and communicating others
Accountant	Managing materials and budget

Project design based on engineering service-learning.

Using their engineering background and higher education knowledge, students create their own perceptions of the proposed solutions. Then, they specify the materials, tools, design process, and also estimate the costs of the product design (Figure 2). The proposed solution must satisfy several criteria. In particular, it must:

- provide a radical solution to the chosen problem;
- represent an engineering solution;
- use available equipment, resources, and funds;
- be installable;
- be accessible to the local community and easy to use (Figure 3); and
- represent a sustainable solution.

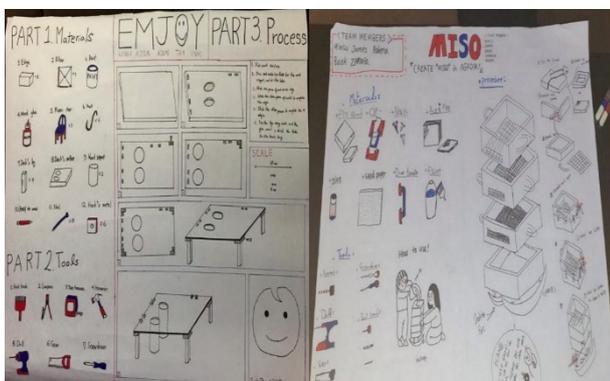


Figure 2. Product design plan.



Figure 3. Final product.

3. Study Methods

Ethics

This study was approved by students through the signing of consent forms. These forms were attached to the surveys and accompanied by a statement explaining that data collected would be used for research and program improvement, and that anonymized data may be shared through publication. Responsibility for ethical integrity was assumed by professors and managers throughout the project.

Data Collection and Recruitment

This research utilizes a mixed-method case study design to gain a comprehensive understanding of the impact of the engineering service-learning approach on the competencies and skills of engineering students. This impact was examined through data collected from all participants in the Smile project. A paper survey was administered to the participating engineering students, achieving a 100% response rate. The survey was given to students twice: first before the project began (pre-survey) to determine the initial state of the competencies, attitudes, and skills to be assessed, and second, after the project was completed (post-survey) to evaluate the level of improvement and degree of achievement.

Survey questions assessed participation, cultural intelligence, experimental analysis, design analysis, engineering knowledge, use of engineering tools, problem solving, multidisciplinary function, communication skills, lifelong learning, professional responsibility, and engineering impact. Additional questions gathered demographic information about the participants. Responses were fully anonymized, and the survey required 8-10 minutes to complete.

Survey Instrument Design and Measures

The survey includes eight main measures, which were then divided into twelve categories, each containing four Likert scale questions, shown in Table 3. This psychometric response scale requires respondents to express their degree of agreement with a statement using a five-point scale: (1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree. The eight measures, also designated by Program Outcomes (POs), are:

Ability to utilize engineering major: The basis on which the importance of any engineering major is built is the need for it, and understanding when and how to apply it. This is how an engineering student realizes the importance of their specialization and how they can adapt their knowledge acquisitions to various situations. This measure was divided into three categories and assigned the largest number of questions (Q1-12).

Ability to solve problems: Engineers must use problem-solving skills to determine the best actions for any given situation. The type of problems that engineers face can differ greatly depending on their engineering specialty. Therefore, there is not a one-size-fits-all approach to solving all problems (Q13-16). Wright suggests a list of commonly included steps that most engineers use in their design process, though not all engineers follow the same steps.

1. Problem identifying.
2. Gather the necessary information.
3. Creative solutions searching.
4. Overcome barriers to creative thinking.
5. Progress from ideas to initial designs (including modelling).
6. Assess and choose a preferred solution.
7. Create reports, plans, and specifications for project planning.
8. Execute the design for project implementation.

Engineering tools usage capability: The ability to use engineering tools properly and to understand when and how to apply them is an essential criterion for assessing an engineer's technical competence and capability (Q17-20).

Interpersonal skills: It refers to behaviours and strategies used by a person to have an effective interaction with others. These skills are essential for an employee in a business context to be able to work well with colleagues. They can include communication, listening, attitude, and deportment (Q21-24).

Communication skills: Having strong communication skills is essential for engineers who wish to practice their profession in a global setting. These skills include fluency in English and a basic understanding of visual communication. Educators and industry professionals have increasingly emphasized the importance of both professional and technical skills for engineering students to

improve community engagement and career success (Q25-28).

Self-management capability: Self-appraisal and the ability to plan, evaluate, and make necessary adjustments and revisions to work are all part of the scope of self-management that contribute to successful cognitive and learning processes (Q29-32) and (Q41-44).

Ability to think synthetically: It requires knowledge of contemporary issues and the contribution of engineering solutions to the economy, the environment, and society (Q33-36) and (Q37-40).

Global capability: It aims to normalize global relations between different nationalities of students, creating an atmosphere of harmony and avoiding cross-cultural misunderstandings (Q45-48).

Statistical Analysis

Data were first compiled in papers and then exported to Statistical Package for the Social Sciences (SPSS) version 28 (IBM, Chicago, IL) for analysis. The reliability of the performance indicators scale was assessed using Cronbach's alpha coefficient, a measure of internal consistency that evaluates how closely related a set of items is as a group. A value close to 1 indicates high reliability, while values below 0.7 are generally considered inadequate (Cronbach, L. J., 1951). The results of the reliability statistics showed high levels of internal consistency, as demonstrated in Table 3, which presents Cronbach's alpha scores for both surveys and their respective subscales.

A normality test was adopted to check whether the data were normally distributed (Table 4). The Kolmogorov-Smirnov test, a non-parametric test, compares the empirical distribution function of the data to the expected theoretical distribution, typically the normal distribution (Massey Jr, F. J., 1951). The Shapiro-Wilk test is used to assess the normality of data, particularly effective for small sample sizes, by evaluating the relationship between observed and expected values under normality assumptions (Shapiro, S. S., & Wilk, M.B., 1965). For the comparison of the means between the two measurements taken from the pre- and post-surveys, the Paired Samples t-Test was applied (Table 5).

Table 3. Cronbach’s Alpha for Scales in Both Pre-and Post-Survey.

	Cronbach 's alpha	
	Pre-survey	Post-survey
Ability to apply knowledge of mathematics, basic science, engineering, and information technology. I can comprehend related knowledge such as mathematics, basic science, and engineering which is used for solving the engineering issues. I can comprehend and solve the engineering issues with my specialty. I can apply engineering knowledge and theory to make a prototype. I can put knowledge and theory into practice in order to demonstrate the effect of made prototype.	0.841	0.863
Ability to design and conduct experiments, as well as to analyze and interpret data. I can collect the data needed for the making the product and analyse it. I can organize elements and detailed plan with analysed data. I can construct and conduct the experiment systematically. I can make a report on issue and result of the engineering experiment.	0.617	0.823
Ability to devise a system, component, or process to meet desired needs within realistic constraints. I can design the products with safety for people in mind. I can define the necessary elements and carry out the phased plan. I can calculate the total time based on the time taken to make each part. I can make a prototype with common materials.	0.630	0.570
Ability to identify, formulate, and solve engineering problems. I am interested in public issue, water, energy, pollution, and food. I can see public issue with my specialty. I can suggest idea and organize detail plan for solving the problems. I can demonstrate and validate the result of solved problem with criteria.	0.224	0.854
Ability to use techniques, skills, and engineering tools necessary for engineering practice. I can make a detail drawing of product by engineering software. I know how to deal with tools needed to make product. I can fix the drawing of product when it needs. I can organize process of making product efficiently with PowerPoint.	0.563	0.754
Ability to function in multi-disciplinary teams. I can organize conducting plan for project on discussion with teammates. I can show leadership to raise quality of our project to a higher level. I can carry out my duty, being assigned within my team. I can do my best to strengthen the unity of the team that consists of different university and nationality.	0.723	0.312
Ability to communicate effectively. I can explain efficiently how to operate and maintain the products. I can organize my idea on systematical document. I can write Product Descriptions so the users can understand. I can make my intention clear to my teammates in project.	0.676	0.628
A recognition of the need for, and ability to engage in life-long learning. I can make continuous study plan based on my future. I can collect learning data and study on my own. I can explain requirement of life-lasting education for self-improvement. I can contribute to the regional society by continuous participating in engineering service.	0.896	0.757
A broad understanding of the impact of engineering solutions in economic, environmental, and societal context I understand how engineering method influence on regional society. I can explain how my specialty will be used in real life. I know how engineering awareness of problem and attempts to solve the problem will be recognized to people. I can understand and explain that recent engineering technology will affect society, economy, and environment.	0.875	0.681
A knowledge of contemporary issues I can explain logically global issues on water, energy, environment pollution, and food. I can collect information on various approaches and use it to solve engineering issues. I understand about the common issues in regional society or underdeveloped country. I can explain about 'engineering service' that solves common issues based on engineering technology.	0.756	0.658
Understanding of professional and ethical responsibilities I can understand if engineers lost their moral sense, it would be severe harm to man. I can explain how sense of responsibility affect society. I can understand importance of moral sense when I perform engineering technology. I can perform my duty with responsibility and work ethic as engineers.	0.728	0.870
Understanding of other cultures and an ability to engage in international cooperation. I can work as team with other countries teammates and accomplish the work together. I can explain about the produced work in English. I can share my thoughts and experience in English. I understand the diversity in culture as citizen of world.	0.955	0.583
Total survey scale	0.931	0.966

Table 4. Normality Tests.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre	0.111	10	0.200*	0.959	10	0.775
Post	0.187	10	0.200*	0.943	10	0.587

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 5. Paired Samples T-test.

		Paired Differences				Significance				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	One-Sided p	Two-Sided p
					Lower	Upper				
Pair1	Pre-Post	0.80720	0.42239	0.13357	0.50504	1.10936	6.043	9	<0.001	<0.001

Quantitative Analysis: The study included descriptive statistics and exploratory data analysis for demographic variables, as well as the capacity to solve problems, using engineering major, self-management, applying engineering tools, and thinking synthetically, and skills of interpersonal, communication, and global capability in socially engaged design were conducted. Regarding normality, the Shapiro–Wilk test results indicate that the data are normally distributed, as the p-value is above 0.05. Paired Sample t-Test indicates a statistically significant difference between pre- and post-survey results, with an advantage to the post-survey. The considered variable is at 1% level of significance as $p < 0.01$. On the other hand, considering Hedges' correction estimate, the pre-and post-scores have a mean difference situated around 1.7 with a Confidence Interval of 95% (0.76-2.10) (Riaji et al., 2022, 2024).

Validation and Reliability of Survey Instrument: All the participants completed the survey. Participation measures included eight domains. We note “n”, the number of questions related to each domain. These domains are: Ability to utilize engineering major (n=12), Ability to solve problems (n=4), Engineering Tools Usage capability (n=4), Interpersonal skill (n=4), Communication skill (n=4), Self-management capability (n=8),

Ability to think synthetically (n=8), and Global capability (n=4). In the pre-survey, both the ability to solve problems and the ability to use engineering tools have unacceptable internal consistency (standard Cronbach’s α) of 0.224 and 0.563, respectively, while only interpersonal skills have unacceptable internal consistency ($\alpha = 0.312$) in the post-survey, whereas the rest of the areas received acceptable to high rates. Both the pre- and post-surveys obtained 0.931 and 0.966, respectively, of the Cronbach’s alpha value, which indicates an excellent level of survey validity and reliability (Taber, 2018; Tavakol & Dennick, 2011). Due to the limited number of responses, confirmatory factor analysis was not conducted (Hurley et al., 1997).

4. Results and Discussion

The average results of the answers for each question have been calculated independently for the pre- and post-surveys. The degree of achievement for each competency and skill was calculated, all of which, except for the skill of controlling engineering software (Q17), had an achievement rate equal to or greater than 0.5. Table 6 shows the results of the average responses from pre- and post-surveys categorized into program outcomes.

Table 6. Descriptive Statistics for Measures of Various Competences in Smile Project 2019.

Competence measure	POs*	Point			Percentage		
		Group 1 Pre (a)	Group 2 Post (b)	achievement degree (b-a)	Group 1 Pre (a)	Group 2 Pre (b)	achievement degree (b-a)
Ability to utilize engineering major	1,2,3	3.14	4.39	1.25	63%	88%	25%
Ability to solve problem	4	3.47	4.19	0.72	69%	84%	14%
Engineering Tools usage capability	5	3.13	3.78	0.66	63%	76%	13%
Interpersonal skill	6	3.47	4.41	0.94	69%	88%	19%
Communication skill	7	3.38	4.38	1.00	68%	88%	20%
Self-management capability	8,11	3.53	4.34	0.81	71%	87%	16%
Ability to think synthetically	9,10	3.30	4.22	0.92	66%	84%	18%
Global capability	12	3.78	4.63	0.84	76%	93%	17%
Total average					68%	86%	18%

*POs- Program Outcomes

The results presented in Table 6 demonstrate significant improvements across all measured competencies, with achievement levels ranging from 13% to 25%, confirming the positive impact of the Smile project on students' engineering skills. The overall paired samples t-test result ($p < 0.001$) supports the statistical relevance of these outcomes. Notably, the ability to utilize engineering majors showed the greatest improvement at 25%, reflecting students' enhanced proficiency in applying theoretical knowledge to practical challenges. Communication skills improved by 20%, highlighting the project's role in fostering teamwork and effective information exchange. Similarly, the ability to solve problems and the capability to use engineering tools increased by 14% and 13%, respectively, illustrating strengthened technical and analytical skills. Gains in interpersonal skills (19%) and self-management capability (16%) indicate better collaboration and personal responsibility. Additionally, improvements in synthetic thinking (18%) and global capability

(17%) demonstrate enhanced critical thinking and cross-cultural collaboration. These results collectively underscore the effectiveness of the Smile project in providing a comprehensive learning experience that advances both technical and soft skills within the framework of Engineering Service-Learning.

The results of Group 1 demonstrate that the participants possess the least competencies and skills, with all target competencies exceeding 63%. This fact suggests that the participating students are carefully selected with a particular set of abilities and skills. Group 2's results are consistently higher than those of Group 1, with all target skills above 76%, indicating that the project had a positive and significant influence on the engineering students. The achievement degree for all target competencies and skills is at least 13%, with an average of 18% (Figure 4) (Riaji et al., 2022).

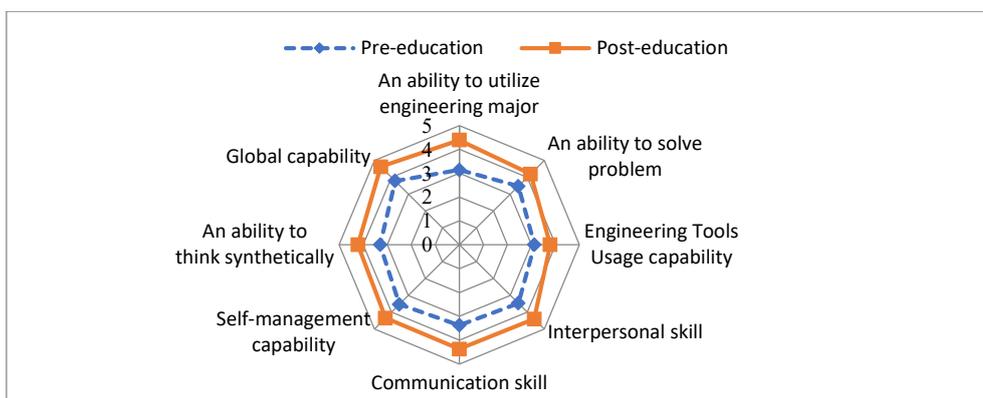


Figure 4. The overall development level of all the skills and competences targeted after the benefits of Smile project 2019.

Satisfaction Level

The post-survey included additional questions (Q49-59) to assess the level of satisfaction of engineering students with respect to the various processes associated with the project and the project as a whole, as shown in Table 7.

Table 7. Satisfaction Post-Survey Result from Smile Project 2019.

Contents of Survey Questionnaire	Result	Cronbach's alpha
The number of reconstructed team members was proper.	4.8	
I enjoyed staying in the accommodations (dormitory).	4.6	
I am satisfied with the team formation.	4.5	
I communicated well.	4.9	
It helped me improve my specialty.	4.4	
After team reconstruction with students in other countries, we could have better teamwork for the mission.	4.6	0.926
The dispatched period was proper.	4.4	
I performed all my duties in the schedule properly.	4.4	
I would like to recommend this program to friends.	4.6	
If I have another chance, I would like to participate again.	4.8	
How satisfied are you with the Smile Project overall?	4.9	

The Cronbach's alpha value ($\approx 93\%$) confirms the excellent reliability and validity of this section of the survey. It also indicates the extent of students' satisfaction (≥ 4.4) with the various processes accompanying the project and the project as a whole (4.9). The students were highly satisfied with the distribution of the teams, the activities and tasks they performed, the positive atmosphere and organization, and their willingness to participate again and to recommend participation to their engineering friends in future editions of the project (Taber, 2018; Tavakol & Dennick, 2011). Note that the satisfaction of professors and managers, along with the satisfaction of engineering students and the local community (based on an interview), is a key factor in evaluating the success of the Smile project in achieving the targeted objectives.

Results Discussion

The conducted study aimed to answer the following question: Do projects involving the engineering service-learning approach have a significant and lasting impact on engineering students' skills and competencies? This research targets the Smile project, which is an implementation of the pedagogical approach of engineering service-learning, in the 2019 edition of this project. A survey was conducted involving participating engineering students of various levels, majors, genders, universities, and countries. Eight skills and competencies, identified as the most important for an engineering student (Samavedham & Ragupathi, 2012), were targeted. A pre-survey was conducted to assess the initial skills status of participating students, and the obtained results were compared with their counterparts in the post-survey. The statistical study found a significant difference between the pre- and post-survey results, favoring the post-survey. This indicates a significant development of the targeted skills and competencies, and therefore a positive impact of the engineering service-learning approach on engineering education (Hedberg & Ayers, 2015; Mowery, 2011). Note that further research with a larger sample size can yield more statistically significant results.

This analysis provided additional insight into the impact of the Smile project in helping students develop their competencies and skills as civic-minded and socially responsible members of society. The quantitative and qualitative results suggest that for the participants, the objectives of engineering service-learning extend well beyond competencies and skills to include citizenship and social responsibility.

To deepen the comparative analysis of our findings, we reference the comprehensive bibliometric study by Hallinger and Kongpiwatana, which examines the evolution of service-learning research indexed in the Scopus database between 1950 and 2022 (Hallinger, P., & Narong, D.K., 2024). This study systematically analyzes 5,815 scholarly documents, highlighting the considerable growth and maturation of the field while noting its primary geographic concentration in economically developed Western countries. The research mainly investigates the design and outcomes of service-learning initiatives, focusing on their influence on students' personal development, social competencies, and academic performance (Astin & Sax, 1998; Billig, 2017). Key reported benefits include improved teamwork, leadership, cultural sensitivity, and a reduction in social biases. Furthermore, service-learning has been demonstrated to foster stronger student-faculty relationships, higher student satisfaction, and deeper community engagement (Bandy, 2016; Gray et al., 1998). These findings collectively emphasize the pedagogical value and societal impact of service-learning as a transformative educational method.

Suppose academics and practitioners are motivated to fully understand and document the value of service-learning as a pedagogical model in engineering education and as a framework for developing skills, competencies, and social responsibility in all disciplines. In that case, it will serve as a strong impetus for engineering education development, and consequently, the graduation of highly qualified students from engineering schools (Dukhan et al., 2008; Maloney et al., 2013; Oz-Medina et al., 2021; Queiruga-Dios et al., 2021; Ropers-Huilman et al., 2005).

Recommendations

Following the obtained results, and in order to improve the Smile project and develop the engineering service-learning approach, we recommend:

- Select participating students through stratified random sampling, a method where items in the target population are divided into distinct groups or strata. Within each stratum, items share similarities in specific characteristics considered important for the survey.
- Conduct a personality test to determine each student's role within the team, in order to place the right person in the correct position.
- Provide students with a broad choice of local communities or issues in order to give them a wide panel of opportunities to apply their specialties.
- Adopt more reliable and accurate methods for assessing the competencies of engineering students, as well as include assessment of the services provided and their impact on the local community.
- Allow students to participate multiple times by multiplying project editions, which will allow an objective observation of outcome improvement for the same students over editions.
- Expand the number of participants to be able to generalize the obtained results.

Limitations

This design study carries limitations regarding the value of this research due to the international nature of the Smile project work, which tends to attract students willing to participate in the project, and participants are selected through an oral interview to ensure they possess a minimum level of skills and abilities required. The latter influences the random method by which participants must be selected and may represent significant viability for the learning development of the selected sample. Furthermore, there is potential for self-selection bias among people who are more favorable to the Smile Project. Due to the small size of the teams compared to the number of data points desired, confirmatory factor analysis was not conducted in our survey.

The method adopted to evaluate different competencies is self-appraisals (by survey), which do not provide precise results. The students' self-appraisals may not correspond closely to their actual performances. Note that this is sometimes referred to as Calibration Error, which is the difference between values indicated by an instrument—the survey in our case—and the actual values. This phenomenon has been repeatedly observed in multiple contexts, including the Kruger-Dunning effect. In psychology, this is a cognitive bias where individuals overestimate their knowledge or competence in a given intellectual or social domain when they initially have limited knowledge or competence in that domain, relative to objective criteria, their

peers' performance, or the general population. Similarly, when maintaining a consistent competency assessment model, the principle of bias mitigation strengthens and improves the validity of results.

Finally, it is important to remember that this is a small-scale, practitioner-driven study limited by time, funds, and staffing resources. Therefore, it does not aim to provide generalizable knowledge but intends to present a perspective yet to be explored. It is hoped that the Engineering Service-Learning methodology will be extended by researchers, professors, and evaluators in various settings to build on participants' experiences in engineering education. While the study is limited in scope and does not aim to produce generalizable knowledge, discussing scalability offers valuable insights. Expanding the participant base would broaden the range of local communities and geographical areas involved, introducing greater diversity in the issues addressed. However, this expansion would complicate project management, making monitoring and follow-up more difficult. Strengthening partnerships between academic institutions and local communities would be essential to ensure effective coordination and sustainable collaboration. Additionally, larger-scale implementations would require enhanced cross-cultural training, improved resource management strategies, and scalable team dynamics, possibly using peer-led leadership or technology-assisted structures. Finally, comprehensive and automated assessment frameworks would be necessary to handle larger data sets while maintaining consistency and accuracy. Addressing these considerations would support the successful adaptation of the Smile project to larger and more diverse educational contexts, enhancing its impact while adhering to the principles of Engineering Service-Learning.

5. Conclusion

This study examines the educational approach known as "Engineering Service-Learning," which can enhance the diverse competencies and skills of engineering students along with traditional educational methods. In their universities, engineering students benefit from theoretical and practical lessons constrained by time and place. The Engineering Service-Learning approach improves the hard and soft skills of engineering students by providing them with the opportunity and suitable conditions to complete and apply what they have learned during their engineering education. The benefit of this approach is not limited to engineering students; it also impacts the local community, which receives sustainable and free solutions to address its issues and develop its activities or projects. This approach also assists professors in giving real meaning to their courses while serving a supervisory and mentoring role. Finally, engineering service-learning remains an effective educational approach that can be adapted to various engineering disciplines. It is also scalable by adding, removing, or modifying its stages and methods to achieve better results.

5. References

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